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Method and Apparatus and Program Storage Device for
Generating a Workflow in response to a User Objective and
Generating Software Modules in response to the Workflow and
Executing the Software Modules to produce a Product

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## CROSS REFERENCE TO RELATED APPLICATIONS

(0001)    This application is a Utility Application of prior pending Provisional

Application serial number 60/482,511 filed 06/25/03 and entitled 'Single Well

15        Predictive Model (SWPM)'.

## BACKGROUND OF THE INVENTION

(0002)    The subject matter of the present invention relates to a software package

20        stored in the memory of a workstation or other computer system, hereinafter

called the "Single Well Predictive Model" or "SWPM", which will enable a user

to introduce a first user objective and a first set of input data, a processor in the

computer system executing the SWPM software in response to the first user

objective and first set of input data, the SWPM software generating a first specific

25        workflow in response the first user objective and executing a first plurality of

software modules which comprise the first specific workflow utilizing the first set

of input data to thereby generate a first product or a result of the execution, the

SWPM software generating a second specific workflow in response a second user

objective and executing a second plurality of software modules which comprise

30        the second specific workflow utilizing a second set of input data to thereby

generate a second product or result of the execution .

(0003)    Generally speaking, during the execution of software in a processor of a

computer system for the purpose of generating a final desired product, it is often

necessary to execute a first software module in the processor of the computer system to produce a first product and then, separately and independently, execute a second software module in the processor in response to the first product to produce a second product, and then, separately and independently, execute a third software module in the processor in response to the second product to produce the final desired product. In order to produce the final desired product, it may be necessary to separately and independently execute in the processor of the computer system a multitude of software modules in order to produce the final desired product. The aforementioned execution of the multitude of software modules, in a separate and independent fashion, is very time consuming and is a very laborious task.

(0004)     Accordingly, there exists a need for a 'software based computer system' (hereinafter called the 'Single Well Predictive Model' or 'SWPM') that will: (1) automatically produce a first specific workflow comprised of a first plurality of software modules in response to a first set of user objectives and automatically execute the first specific workflow in response to a first set of input data to produce a first desired product, and (2) automatically produce a second specific workflow comprised of a second plurality of software modules in response to a second set of user objectives and automatically execute the second specific workflow in response to a second set of input data to produce a second desired product.

(0005)     When the SWPM software based computer system is utilized, there would no longer be any need to separately and independently execute the first plurality of software modules of the first workflow in order to produce the first desired product, and there would no longer be any need to separately and independently execute the second plurality of software modules of the second workflow in order to produce the second desired product. As a result, a considerable amount of processor execution time would be saved and, in addition, there would no longer be any need to perform the aforementioned laborious task of separately and

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independently executing a plurality of software modules in order to produce a final desired product.

(0006)    The aforementioned 'software based computer system' of the present invention, known as the 'Single Well Predictive Model' or 'SWPM', is adapted for use in the oil industry.  In the oil industry, ideally, all production activities performed in connection with a well should utilize any knowledge concerning the reservoir (e.g., timely pressure interference and rock heterogeneity) adjacent to the well being drilled.  However, as a result of the absence of a common three-dimensional (3D) predictive model that can be used not only by reservoir engineers but also by production/drilling/well services engineers, the gap between the reservoir knowledge and day-to-day well decisions remains one of the most significant sources of inefficiency in field management and in field operations.  Due to a similar gap between reservoir modeling and production modeling, it is our understanding that clients rarely utilize much of the data that has been acquired - they certainly don't maximize what can be interpreted from that data.  Furthermore, most of the reservoirs do not have a realistic reservoir predictive model.  It is estimated that only 20% of producing reservoir fields have a reservoir model.  This indicates that most of the reservoir fields are operated on the basis of knowledge about individual wells.  There are a number of reasons for this, chief among them being: the need for necessary experienced personnel, the need for 'fit-for-purpose' software, the sheer size of the reservoir models, and the time required.

(0007)    Accordingly, there exists a need for a 'Single Well Predictive Model' or 'SWPM' software based computer system that will enable a company's staff to get closer to well operations while empowering them with fast interpretation tools utilizing all available data and 3D reservoir models built around a specific well thus enhancing the quality of decisions in field management.  The 'SWPM' software based computer system represents an opportunity for a company to differentiate itself in the market by 'adding value', where such value is added by

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introducing a new interpretation service (i.e., the SWPM software) to the company's current and future data acquisition tools and services. In addition, the 'real-time capability' associated with the 'Single Well Predictive Model (SWPM)' software based computer system will be appreciated and utilized significantly in the oil industry because the oil industry as a whole is rapidly progressing toward an 'on-time' and 'data-to-decision' work environment. Finally, the attributes of the 'SWPM' software based computer system of the present invention, including integration and interactiveness and intuitiveness, will be considered when the next generation of 'field predictive models' is created. In addition, there exists a need for an interactive and intuitive flow simulation based 'Single Well Predictive Model (SWPM)' which is used for the purpose of integrating static and dynamic measurements with completion data that can be used by non-reservoir simulation experts. The SWPM will enable the building of 3-D comparative prediction models starting from 1-D information (i.e. from the well). The SWPM will read the formation information of the subject well and create a reservoir flow model for the selected drainage area of the well. From 1 D to 3D, property creation will be done stochastically and then fine-tuned with respect to the available dynamic data of the well. Once the most likely reservoir properties are estimated, SWPM can be used to investigate various predictive scenarios, such as customizing completion strategy, investigating drilling strategy, predicting well performance considering the impact on the reservoir, demonstrating the value of additional data on decision making, and demonstrating the value of new technologies. SWPM will be built around optimized workflows including, petrophysical property estimation, static model construction, model tuning, drilling, completion, production, or intervention. Ease of use and intuitiveness are of utmost importance. SWPM will be used either sequentially in elapsed time mode, or in fully automatic real-time mode.

## SUMMARY OF THE INVENTION

(0008)     Accordingly, one aspect of the present invention involves a method for determining a desired product corresponding to a user objective, comprising the steps of: (a) providing a first user objective; (b) providing a first set of input data; (c) automatically generating a first workflow in response to the first user objective; (d) automatically selecting one or more software modules in response to the first workflow; (e) executing the one or more software modules in a processor in response to the first set of input data; and (f) determining a first desired product in response to the executing step (e).

(0009)     A further aspect of the present invention involves a program storage device readable by a machine tangibly embodying a set of instructions executable by the machine to perform method steps for determining a desired product corresponding to a user objective, the method steps comprising: (a) receiving a first user objective; (b) receiving a first set of input data; (c) automatically generating a first workflow in response to the first user objective; (d) automatically selecting one or more software modules in response to the first workflow; (e) executing the one or more software modules in a processor in response to the first set of input data; and (f) determining a first desired product in response to the executing step (e).

(0010)     A further aspect of the present invention involves a system responsive to a set of input data and a user objective adapted for generating a desired product corresponding to the user objective, comprising: first apparatus adapted for receiving a first user objective and a first set of input data; second apparatus adapted for automatically generating a first workflow in response to the first user objective; third apparatus adapted for automatically selecting one or more software modules in response to the first workflow; and processor apparatus adapted for automatically executing the one or more software modules in

response to the first set of input data and generating a first desired product in response to the execution of the one or more software modules.

(0011)    A further aspect of the present invention involves a method for determining a final product in response to a user objective, comprising the steps of: (a) providing the user objective and providing input data; (b) generating a specific workflow corresponding to the user objective; (c) selecting a plurality of software modules in response to the specific workflow, the plurality of software modules having a predetermined sequence; (d) executing the plurality of software modules in the predetermined sequence in response to the input data; and (e) generating the final product when the execution of the plurality of software modules in the predetermined sequence is complete.

(0012)    A further aspect of the present invention involves a program storage device readable by a machine tangibly embodying a set of instructions executable by the machine to perform method steps for determining a final product in response to a user objective, the method steps comprising: (a) providing the user objective and providing input data; (b) generating a specific workflow corresponding to the user objective; (c) selecting a plurality of software modules in response to the specific workflow, the plurality of software modules having a predetermined sequence; (d) executing the plurality of software modules in the predetermined sequence in response to the input data; and (e) generating the final product when the execution of the plurality of software modules in the predetermined sequence is complete.

(0013)    A further aspect of the present invention involves a system adapted for determining a final product in response to a user objective, comprising: first apparatus adapted for receiving the user objective and receiving input data; second apparatus adapted for generating a specific workflow corresponding to the user objective; third apparatus adapted for selecting a plurality of software modules in response to the specific workflow, the plurality of software modules having a predetermined sequence; fourth apparatus adapted for executing the plurality of software modules in the predetermined sequence in response to the

input data; and fifth apparatus adapted for generating the final product when the execution of the plurality of software modules in the predetermined sequence is complete.

(0014) Further scope of applicability of the present invention will become apparent from the detailed description presented hereinafter. It should be understood, however, that the detailed description and the specific examples, while representing a preferred embodiment of the present invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become obvious to one skilled in the art from a reading of the following detailed description.

## BRIEF DESCRIPTION OF THE DRAWINGS

(0015) A full understanding of the present invention will be obtained from the detailed description of the preferred embodiment presented hereinbelow, and the accompanying drawings, which are given by way of illustration only and are not intended to be limitative of the present invention, and wherein:

(0016) figure 1 illustrates a workstation or other computer system representing the Single Well Predictive Model (SWPM) software based computer system of the present invention;

(0017) figure 2 illustrates the products generated by the recorder or display device of the computer system of figure 1;

(0018) figure 3 illustrates a simple example of model building and its ultimate purpose which is utilized by the SWPM software based computer system of figure 1;

(0019)    figure 4 illustrates a simple example of the construction and the functional operation of the SWPM software based computer system which stores the SWPM software illustrated in figure 1;

(0020)    figure 5 illustrates a detailed construction of the SWPM software stored in the SWPM software based computer system of figure 1;

(0021)    figure 6 illustrates the relationship between the Data Conditioner, the Decision Tool, and the Workflow Harness; this figure showing how the Data Conditioner and the Decision Tool are connected;

(0022)    figure 7 illustrates a schematic diagram of the Data Conditioner; this figure illustrating how multi-domain data coming from various sources (logs, image logs, MDT measurement, cores and production logs) will be processed to create a 'calibrated consistent 1-D petrophysical static model';

(0023)    figure 8 illustrates the one-dimensional (1D) product of the Data Conditioner; this figure being a draft of how the Data Conditioner results are visualized;

(0024)    figure 9 illustrates the steps, within the Decision Tool, which are taken in response to the 1-D product output of the Data Conditioner shown in figure 8; this figure showing how the Data Conditioner and the Decision Tool are connected (a detailed version of figure 6); it shows the steps to be taken to create product 'decisions' out of the Decision Tool;

(0025)    figure 9A illustrates the architecture of the SWPM software shown in figures 1, 4-6; this figure showing how existing software and new software are organized (integrated) in a specific order to create the Single Well Predictive Model (SWPM); this basically shows the engines in the background; the SWPM

will use the software in a specific order (which is set according to the Decision Tool) while executing;

(0026)    figures 10 and 11 illustrate a more detailed construction and functional operation of the SWPM software stored in the SWPM software based computer system of figure 1; and

(0027)    figures 12 through 17 illustrate examples of the functional operation of the SWPM software based computer system of figure 1 which stores the SWPM software of the present invention shown in figures 5, 10, and 11.

(0028) The Single Well Predictive Model (SWPM) software based computer system of the present invention, which stores the Single Well Predictive Model (SWPM) software of the present invention will: (1) automatically produce a first specific workflow comprised of a first plurality of software modules in response to a first set of user objectives and automatically execute the first specific workflow in response to a first set of input data to produce a first desired product, and (2) automatically produce a second specific workflow comprised of a second plurality of software modules in response to a second set of user objectives and automatically execute the second specific workflow in response to a second set of input data to produce a second desired product. As a result, there is no longer any need to separately and independently execute the first plurality of software modules of the first workflow in order to produce the first desired product, and there is no longer any need to separately and independently execute the second plurality of software modules of the second workflow in order to produce the second desired product. As a result, a considerable amount of processor execution time is saved and, in addition, there is no longer any need to perform the aforementioned laborious task of separately and independently executing a plurality of software modules in order to produce a final desired product.

(0029) In addition, the Single Well Predictive Model (SWPM) software based computer system of the present invention, which stores the Single Well Predictive Model (SWPM) software of the present invention, will provide a workflow for the less specialized engineer for the purpose of building a model intuitively which can subsequently be used to predict production performance. The SWPM software of the present invention includes four modules: (1) a Data Entry module used for the purpose of introducing 'input data', (2) a Model Creation module used for the purpose of generating a 'Specific Workflow', (3) a Model Calibration module used as a 'Data Conditioner', and (4) a Solutions module used as a 'Decision

Tool'. Those modules are supported by a Workflow Storage database which includes a background knowledge database and processes guidance system. According to the 'execution type' (e.g., sequential or real-time) and a chosen 'User-objective' which is provided by a user (e.g., Completion Optimization, Stimulation Optimization, Data Valuation, Test Design, Well Reserve & Recovery Estimator, etc), the user will provide 'input data' guided by a 'specific workflow' representing the selected solution workflow. Data Entry (which provides the 'input data') will provide options to the user, including knowledge base and constant property values. When the 'input data' is introduced by the user into the Data Entry module and when the 'User-objective' is provided by the user, a 'specific workflow' will be generated in the Model Creation module wherein a reservoir model around the subject well will be built automatically. The user, as an option, can guide the reservoir model building. Based on the ranges of input data, possible realizations of the reservoir model will be built and provided to the user for selection. The SWPM software will offer a selection methodology or alternatively, the user may choose to retain all realizations. When the 'specific workflow' model is generated in the Model Creation module, a 'Data Conditioner' will be provided wherein validation of the model (represented by the 'specific workflow') to observed transient and/or production data will be available in the Model Calibration module. When the representative reservoir flow model is in place (i.e., the 'Data Conditioner' has completed its function), the simulator can now be used to achieve the original objective selected at the beginning of the session. Alternatively, the user can choose to investigate other optimization scenarios in the Solutions module, also known as the 'Decision Tool'. A set of results are generated by the 'Decision Tool' in the Solutions module. The set of results generated by the 'Decision Tool' in the Solutions module include a series of predictions which are based on the operations and/or completion scenarios that were provided by the user. The 'real-time' version of the Single Well Predictive Model (SWPM) will be able to build consecutive predictive models for specified intervals during the drilling process. The intervals can either be manually chosen or triggered by a geological / petrophysical (rock - fluid) property. Predictive

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models built during a drilling operation will be saved and be accessible for comparative analysis. A Single Well Predictive Model (SWPM) is an integrated and intuitive software tool that will be enable the user to build the following for an oil/gas well: (1) starting from well logs and other tests, determining storage and conductivity properties in the reservoir around the well bore, (2) constructing a 3D reservoir model around the well bore, and (3) forecasting the performance of the well under various completion and production scenarios (each of these three activities can be done manually with the help of many different software tools). When this stage is reached, the model can then be used for numerous forecasts that can lead to useful decisions, such as (1) where to complete the well for optimizing production, (2) selection of well completion tubular for ensuring the planned production, (3) Modular Dynamic Tester (MDT) and Pressure Transient Test interpretations, (4) Production and pressure test design, and (5) Estimating the reserve around the well bore while drilling (this list can be expanded). The Single Well Predictive Model (SWPM) is an interactive and special guide system that will lead the user from a 'data end' to a 'decision end'. During this interactive journey, the SWPM will have access to numerous software tools in the background. The Single Well Predictive Model (SWPM) software includes: (1) a Data Conditioner, (2) a Decision Tool and (3) a Workflow Harness. The relationships between the Data Conditioner and the Decision Tool and the Workflow Harness will be discussed in the following sections of this specification.

(0030)    Referring to figures 1 and 2, a workstation or other computer system 20 is illustrated in figure 1. In figure 1, the workstation or other computer system 20 includes a processor 20a connected to a system bus, a recorder or display device 20b connected to the system bus, and a program storage device 20c, such as a memory 20c, connected to the system bus. The program storage device/memory 20c stores a software package therein known as the 'Single Well Predictive Model (SWPM)' software 20c1. The system bus will receive 'Input Data' 22, such as wellbore data, and the system bus will also receive a set of 'User Objectives' 24.

In figure 2, the recorder or display device 20b of figure 1 will ultimately generate, produce, or display one or more 'products produced for each User Objective' 20b1. In operation, with reference to figures 1 and 2, a user will enter the following information into the workstation/computer system 20 of figure 1: the 'Input Data' 22 and the 'User Objectives' 24. When the user provides both the 'Input Data' 22 and the set of 'User Objectives' 24, the processor 20a of the workstation/computer system 20 will execute the 'Single Well Predictive Model' software 20c1 (hereinafter, the SWPM software 20c1) and, when that execution is complete, the recorder to display device 20b of figures 1 and 2 will generate, produce, or display the 'products produced for each User Objective' 20b1. That is, a unique 'product' 20b1 of figure 2 will be generated by the recorder or display device 20b corresponding to each 'User Objective' 24. The workstation or computer system 20 of figure 1 may be a personal computer (PC), a workstation, or a mainframe. Examples of possible workstations include a Silicon Graphics Indigo 2 workstation or a Sun SPARC workstation or a Sun ULTRA workstation or a Sun BLADE workstation. The program storage device 20c/memory 20c is a computer readable medium or a program storage device which is readable by a machine, such as the processor 20a. The processor 20a may be, for example, a microprocessor, microcontroller, or a mainframe or workstation processor. The memory 20c, which stores the SWPM software 20c1, may be, for example, a hard disk, a ROM, a CD-ROM, a DRAM, or other RAM, a flash memory, a magnetic storage, an optical storage, registers, or other volatile and/or non-volatile memory.

(0031)    Referring to figure 3, a simple example of model building and its ultimate use or purpose, which is utilized by the SWPM software 20c1 stored in the software based computer system 20 of figure 1, is illustrated. In figure 3, the simple example of computer model building and its use includes a plurality of steps. In a first step 26 entitled 'variable/alternative data' 26, one must first decide 'what do you want to evaluate', step 26a. For example, what reservoir field do you want to evaluate? Then, in step 26b, the 'data entry' phase 26b will begin, the data being entered via the 'data entry' step 26b (into the computer

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system of figure 1) corresponding to the entity which one has decided, in step 26a, to evaluate. In a second step 28 entitled 'geological uncertainty', when the 'data entry' step 26b is complete, one must first 'build models' in step 28a. In step 28a, your computer models must first be constructed, and, in step 28b 'verification of reservoir models', your computer model must be verified to ensure that it will produce accurate results. Upon completion of steps 28a and 28b, a 'verified model' has been constructed and tested. The next steps 28c and 28d involve a real-time use of your 'verified model', and that real-time use of your 'verified model' will include the following activity: iterating on various completion or production or operational alternatives.

(0032)    Referring to figure 4, a simple example of one aspect of the construction and the functional operation of the SWPM software based computer system 20 which stores the SWPM software 20c1 of figure 1 is illustrated. In figure 4, the Single Well Predictive Model software 20c1 of figure 1 includes four basic steps: (1) a welcome station 30, (2) a Data Entry step 32, (3) a single well predictive model construction and execution step 34, and (4) a solutions step 36 involving a presentation of generated 'solutions'. In the welcome station step 30 in figure 4, the user must decide 'what do you wish to investigate?'. The SWPM software 20c1 is a dynamic well tool kit which will enable a user to perform: test design, completion optimization, and stimulation optimization. The SWPM 20c1 is an incremental data valuator having multi-purpose sensitivity and it can be a productivity/reserve estimator 'while drilling'. In the data entry step 32 of figure 4, when the user decides to investigate a 'particular entity' (such as a reservoir field) during the welcome station step 30, a plurality of 'input data' is entered into the computer system 20 of figure 1 corresponding to that 'particular entity', such as 'well data' 32a and 'reservoir data' 32b, thereby creating and storing a 'supplementary knowledge database' 32c. When the 'supplementary knowledge database' 32c is created during the data entry step 32 in response to a set of 'input data' provided by a user (including the aforementioned 'well data' 32a and 'reservoir data' 32b), the next step 34 involves 'model building' and using the

recently-built model to perform 'multi-domain integrated execution' 34b. In the Single Well Predictive Model (SWPM) construction step 34 of figure 4 (also called the 'model construction and execution' step 34), a 'predictive model' 34a is constructed. When the 'predictive model' 34a is constructed, the 'input data' of step 32 (i.e., the 'well data' 32a and the 'reservoir data' 32b and other data stored in the 'supplementary knowledge database' 32c) is used to 'interrogate' the 'predictive model' 34a during the 'multi-domain integrated execution' step 34b. That is, the 'well data' 32a and the 'reservoir data' 32b stored in the 'supplementary knowledge database' 32c of step 32 are used to 'interrogate' the 'predictive model' 34a to produce a set of results, where the set of results may include: 'petrophysical property determination' 34c or 'static framework and property distribution' 34d or 'transition to Flow and Equilibration' 34e, or 'Dynamic Data Verification' 34f. The results of that 'interrogation' of the 'predictive model' 34a (including the results generated during steps 34c, 34d, 34e, and 34f) will be presented to the user during the following 'solutions' step 36. In the SWPM 'solutions' step 36, the results of the 'interrogation' of the 'predictive model' 34a, which was performed during 'model construction and execution' step 34, are presented to a user during this 'solutions' step 36. Possible 'solutions' presented during this step 36 may include test design, completion, stimulation, data valuation, sensitivity, productivity/reserve estimator while drilling, etc. However, later in this specification, it will be demonstrated that the 'predictive model' 34a will first be constructed in response to a set of 'User Objectives' and, when the 'predictive model' 34a is constructed, the 'well data' 32a and the 'reservoir data' 32b stored in the 'supplementary knowledge database' 32c of step 32 will then be used to 'interrogate' the newly constructed 'predictive model' 34a to produce the set of results. A more detailed construction of the 'Single Well Predictive Model (SWPM)' software 20c1 of figures 1 and 4 will be set forth in the following paragraphs of this specification with reference to figures 5 through 17 of the drawings.

(0033)    Referring to figure 5, a detailed construction of the SWPM software 20c1
of figures 1 and 4 which is stored in the SWPM software based computer system
20 of figure 1 is illustrated.   In figure 5, the Single Well Predictive Model
(SWPM) software 20c1 includes a workflow storage 40 adapted for storing a
plurality of different workflows (where the term 'workflow' will be defined
below) and adapted for generating a 'specific workflow selected in response to
User Objectives and input data' 42.   The SWPM software 20c1 also includes a
workflow harness 44 adapted for receiving the 'specific workflow' from step 42
and, responsive to that 'specific workflow' from step 42, selecting a plurality of
different software modules from the Data Conditioner and the Decision Tool in
response to and in accordance with that 'specific workflow' (to be discussed in
greater detail in the paragraphs to follow).   The SWPM software 20c1 further
includes a Data Conditioner 46 which is adapted for storing therein a plurality of
software modules, including the following nine software modules which are
illustrated in figure 5 for purposes of discussion only since a multitude of
software modules can be stored in the Data Conditioner 46: software module1,
software module 2, software module 3, software module 4, software module 5,
software module 6, software module 7, software module 8, and software module
9. The software modules which are stored in the Data Conditioner 46 and are
selected by the Workflow Harness 44 will 'condition' (e.g., calibrate) the 'Input
Data' 22. When the 'Input Data' 22 is properly 'conditioned', the selected
software modules stored in the Data Conditioner 46 will generate certain
particular 'Data Conditioner Products' 48.   The SWPM software 20c1 further
includes a Decision Tool 50 which is adapted for receiving the 'Data Conditioner
Products' 48 and storing therein a further plurality of software modules, including
the following nine software modules which are illustrated in figure 5 for purposes
of discussion only since a multitude of software modules can be stored in the
Decision Tool 50: software module10, software module 11, software module 12,
software module 13, software module 14, software module 15, software module
16, software module 17, and software module 18.   The Decision Tool 50 will
ultimately generate 'Decision Tool Products for each Objective' 20b1 which

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represent the 'Products produced for each User Objective' 20b1 of figure 2. A complete description of the functional operation of the SWPM software 20c1 of figure 5 of the present invention will be set forth in later sections of this specification with reference to figures 12 through 17 of the drawings. However, the following paragraphs of this specification with reference to figures 6 through 11 will provide further details with respect to the structure and the function of the SWPM software 20c1 of figure 5 of the present invention.

(0034)    Referring to figures 6, 7, 8, 9, and 9A, recalling that the SWPM software 20c1 of figures 1, 4, and 5 include a Data Conditioner 46, a Decision Tool 50, and a Workflow Harness 44, figure 6 illustrates the relationships between the Data Conditioner 46, the Decision Tool 50, and the Workflow Harness 44, figure 6 showing how the Data Conditioner 46 and the Decision Tool 50 are connected. In figure 6, the Decision Tool 50 includes a Static Model Builder and an Interpretation, Forecasting, and Analysis tool. Figure 7 illustrates how multi-domain data coming from various sources, (such as logs, image logs, Modular Dynamic Tester (MDT) measurements, cores, and production logs) will be processed to create a 'calibrated consistent 1-D petrophysical static model'. In figure 7, if we look at the key pieces in more detail, the Data Conditioner 46 will provide the 1D (one-dimensional) reservoir properties measured at the well bore. All data will be integrated and interpreted in the Data Conditioner 46 as the beginning of the SWPM execution. Schematically, the Data Conditioner 46 is illustrated in figure 7. In figure 8, the 1D product output of the Data Conditioner 46 is illustrated in figure 8. Figure 8 shows how a 'set of results' generated by the Data Conditioner 46 will be visualized. Figure 9 shows how the Data Conditioner 46 and the Decision Tool 50 are connected, figure 9 representing a detailed version of figure 6. In particular, figure 9 shows the steps to be taken to generate product 'decisions-reports' from the Decision Tool 50. In figure 9, the 1D product output of the Data Conditioner 46 shown in figure 8 will begin the execution of the Decision Tool 50. The steps within the Decision Tool 50,

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starting with the 1D product output of the Data Conditioner 46 of figure 8, is illustrated in figure 9.

(0035)    The third module of the SWPM software 20c1 is the Workflow Harness 44. The Workflow Harness 44 will guide the user from the beginning of the session to the end. Once the user chooses the 'User Objective' from the list provided by the Workflow Harness 44, the Workflow Harness 44 will then call for an 'appropriate workflow' from within a database, and the execution of the SWPM software 20c1 will follow along that 'appropriate workflow'. The 'appropriate workflow' will call numerous application softwares in the right and optimum order. The input/output protocol from one application software to another will also be arranged by the Workflow Harness 44. Figure 9A shows how a plurality of 'software modules' are organized or integrated together in a specific order or arrangement to thereby create a Single Well Predictive Model (SWPM). Figure 9A basically shows the 'software modules' in the background. The SWPM will use the 'software modules' in a 'specific order' while executing. The 'specific order' is established by the Decision Tool. In figure 9A, from a software structure point of view, a simplified illustration of the architecture of the SWPM software 20c1 of the present invention is illustrated. In figure 9A, the 'Basic Simulation Environment' including the 'Case/Data Tree', 'Run Manager', 'Data Manager', and 'Results Viewer' can be found in U.S. Patent Application serial number 09/270,128 filed March 16, 1999, entitled "Simulation System including a Simulator and a Case Manager adapted for Organizing Data Files for the Simulator in a Tree-Like Structure", the disclosure of which is incorporated by reference into the specification of this application. In figure 9A, the 'SWPM' is the 'Single Well Predictive Model' software 20c1 disclosed in this specification.

(0036)    Referring to figures 10 and 11, a more detailed construction of the structure and the functional operation of the SWPM software 20c1 stored in the SWPM software based computer system 20 of figures 1 and 5 is illustrated. In figure 10,

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the SWPM software 20c1 includes the introduction, by a user, of a set of User Objectives 24.

(0037)    In figures 10 and 11, when the User Objectives 24 are input to the SWPM computer system 20 of figure 1, the user will interactively monitor the progress of the execution of the SWPM software 20c1 via the 'Rule Based Project Execution Guide System – Interactive/ Automatic' 52. When the user interactively monitors the progress of execution of the SWPM software 20c1 via the 'Rule Based Project Execution Guide System' 52, the user always stays at that level, since the user is guided by the system, as indicated by step 53 of figure 11. Estimated results 55 are generated, as indicated by step 55 of figures 10 and 11. The results 55 are reported, and the session is over, as indicated by step 57 in figure 11.

(0038)    In figures 10 and 11, in addition to the set of User Objectives 24, the user will also provide the 'input data' represented by the 'well data' step 22 in figure 10. In response to the User Objectives 24 and the 'well data' 22, a 'selected workflow' 42 will be chosen from a plurality of workflows stored in the 'custom workflow storage' 40, the 'selected workflow' 42 representing a 'custom workflow' 54. The 'custom workflow' 54 will execute a 'first plurality of selected software modules' which exist along a first path 56 in the Data Conditioner 46 thereby generating the Data Conditioner Products (per depth) 48, and the 'custom workflow' 54 will also execute a 'second plurality of selected software modules' which exist along a second path 58. The Data Conditioner Products 48, per unit of depth, include porosity, permeability, relative permeability, rock type, lithology, layering, PVT, Pi, WOC, GOC, etc. In figure 10, the Data Conditioner 46 includes: (1) methodologies 46a, (2) software modules 46b, and (3) Data and Input/Output 46c. The Decision Tool 50 also includes: (1) methodologies 50a, (2) software modules 50b, and (3) Data and Input/Output 50c. In response to the 'User Objective' 24 provided by the user and the 'Well Data' also provided by the user, and when the 'first plurality of software modules' along the first path 56 are executed by the processor 20a of figure 1, the 'second plurality of software

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modules' along the second path 58 will then be executed by the processor 20a of figure 1. When the 'second plurality of software modules' along the second path 58 is executed, a 'Decision Tool Product' 20b1 is generated which corresponds to the 'User Objective' 24 which is selected and provided by the user. In figure 11, the aforementioned functional operation of the SWPM software 20c1 discussed above with reference to figure 10 (whereby a 'User Objective' 24 and 'Input Data' in the form of 'Well Data' 22 are provided by the user and, responsive thereto, a corresponding 'custom workflow' 54 is generated from the workflow storage 40, the 'custom workflow' 54 being executed along two paths 56 and 58 in the Data Conditioner 46 and the Decision Tool 50 thereby generating 'Decision Tool Products' 20b1) is illustrated again in figure 11. In figure 11, a plurality of 'steps' associated with the functional operation of the SWPM software based computer system 20 of figure 1 which occurs when the SWPM software 20c1 is executed will be discussed below. In figure 11, step 60 in connection with the 'User Objectives' 24 indicates that the user must first introduce information corresponding to the 'request' where the term 'request' means the 'objective of the project' or the 'User Objective' 24. Step 62 indicates that 'input data' in the form of 'well data' 22 must then be introduced into the SWPM software based computer system 20 of figure 1. Step 64 indicates that, in response to the 'request' or 'User Objective' 24 and the 'input data' or the 'well data' 22 provided by the user and entered into the SWPM software based computer system 20 of figure 1, the appropriate 'workflow' is automatically selected from the 'workflow storage' 42. Step 66 indicates that 'progress' will follow the path of the 'selected workflow'; that is, a 'first plurality of software modules' will be selected from the Data Conditioner 46 and a 'second plurality of software modules' will be selected from the Decision Tool 50 in accordance with the 'selected workflow', the 'first plurality of software modules' and the 'second plurality of software modules' being executed in sequence by the processor 20a of the SWPM software based computer system 20 of figure 1. Step 68 indicates that, when the 'first plurality of software modules' of the Data Conditioner 46 are executed by the processor 20a of figure 1, one-dimensional (ID) well model properties are estimated in the Data

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Conditioner 46 'multi dimensional solution system'. Step 70 indicates that, when the 'first plurality of software modules' of the Data Conditioner 46 are executed by the processor 20a of figure 1 and when the resultant one-dimensional (ID) well model properties are estimated in the Data Conditioner 46 'multi dimensional solution system' in response to the completion of the execution of the 'first plurality of software modules' of the Data Conditioner 46, a 'set of results' which are produced by the Data Conditioner 46 are collected in the Data Conditioner Products 48, that 'set of results' being ready for use in connection with 'reservoir modeling'. Step 72 indicates that, in response to the 'set of results' which have been collected in the Data Conditioner Products 48, the 'second plurality of software modules' in the Decision Tool 50 (which were selected from among other software modules in the Decision Tool 50 in accordance with the 'selected workflow' 42) will be executed in sequence by the processor 20a of figure 1 in accordance with the established 'User Objective' 24, and, as a result, processing within the Decision Tool 50 of the one-dimensional (ID) data and other dynamic data will now begin. Step 74 indicates that, when the processing within the Decision Tool 50 of the one-dimensional (ID) data and other dynamic data is complete, a 'second set of results' is generated by the Decision Tool 50 is collected, the 'second set of results' being ready for use for the ultimate purpose of formulating one or more recommendations which can be made to field personnel.

(0039)    Referring to figures 12 through 17, a functional description of the operation of the Single Well Predictive Model (SWPM) software based computer system 20 of figure 1, including the Single Well Predictive Model (SWPM) software 20c1 of figures 1 and 5 stored in the computer system 20, will be set forth in the following paragraphs with reference to figures 12 through 17 of the drawings.

(0040)    In figures 12 through 17, the Single Well Predictive Model (SWPM) software 20c1 of figures 1 and 5 is illustrated. The Single Well Predictive Model (SWPM) software based computer system 20 of the present invention as shown in

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figure 1, which stores the Single Well Predictive Model (SWPM) software 20c1 of the present invention will: (1) automatically produce a first specific workflow comprised of a first plurality of software modules in response to a first set of user objectives and automatically execute the first specific workflow in response to a

5    first set of input data to produce a first desired product, and (2) automatically produce a second specific workflow comprised of a second plurality of software modules in response to a second set of user objectives and automatically execute the second specific workflow in response to a second set of input data to produce a second desired product. As a result, there is no longer any need to separately

10    and independently execute the first plurality of software modules of the first workflow in order to produce the first desired product, and there is no longer any need to separately and independently execute the second plurality of software modules of the second workflow in order to produce the second desired product. As a result, a considerable amount of processor execution time is saved and, in

15    addition, there is no longer any need to perform the aforementioned laborious task of separately and independently executing a plurality of software modules in order to produce a final desired product.

(0041)    In figures 12-17, recall that the Single Well Predictive Model (SWPM)

20    software 20c1 of figures 1, 5, and 12-17 includes a Data Conditioner 46 which generates Data Conditioner Products 48, a Decision Tool 50, and a Workflow Harness 44 operatively connected to the Data Conditioner 46 and the Decision Tool 50, the function of which will be discussed below.

25    (0042)    In figure 12, assume that the user introduces, as input data, the following information into the Single Well Predictive Model (SWPM) software based computer system 20 of figure 1: (1) a first set of User Objectives (i.e., User Objective 1) 24a, and (2) a first set of Input Data (i.e., Input Data 1) 22a. The first set of Input Data 22a are input to the workflow harness 44. The first set of

30    User Objectives 24a are input to the Workflow Storage 40, and, responsive thereto, a first specific workflow (specific workflow 1) 42a corresponding to the

first set of User Objectives 24a is generated from the workflow storage 40, the first specific workflow 42a being input to the Workflow Harness 44. Recall that the Data Conditioner 46 includes a 'first plurality of software modules' 46a including the following software modules: software module 1, software module 2, software module 3, software module 4, software module 5, software module 6, software module 7, software module 8, and software module 9. Recall that the Decision Tool 50 includes a 'second plurality of software modules' 50a including the following software modules: software module 10, software module 11, software module 12, software module 13, software module 14, software module 15, software module 16, software module 17, and software module 18. In response to the first specific workflow 42a, the workflow harness 44 will choose 'certain selected ones of the first plurality of software modules' 7, 4, 5, 2, and 3 embodied within the Data Conditioner 46. In figure 12, the 'certain selected ones of the first plurality of software modules' 7, 4, 5, 2, and 3 consist of the following software modules: software module 7, software module 4, software module 5, software module 2, and software module 3. Then, in response to the first specific workflow 42a, the workflow harness 44 will also choose 'certain selected ones of the second plurality of software modules' 16, 13, 14, 11, and 12 embodied within the Decision Tool 50. The 'certain selected ones of the second plurality of software modules' 16, 13, 14, 11, and 12 consist of the following software modules: software module 16, software module 13, software module 14, software module 11, and software module 12. The 'certain selected ones of the first plurality of software modules' 7, 4, 5, 2, and 3 embodied within the Data Conditioner 46 will be executed first by the processor 20a of the computer system 20 of figure 1 in response to the 'Input Data 1' 22a thereby generating the Data Conditioner Products 48. The Data Conditioner Products 48 will include and will therefore generate a set of 'Conditioned Data' 48a (e.g., calibrated data). Then, in response to the 'Conditioned Data' 48a, the 'certain selected ones of the second plurality of software modules' 16, 13, 14, 11, and 12 embodied within the Decision Tool 50 will then be executed by the processor 20a of the computer

system 20 of figure 1 (while using the Conditioned Data 48a) thereby generating the 'Decision Tool Product for User Objective 1' 20b1A.

(0043)    In figure 13, the 'specific workflow 1' 42a of figure 12, including the 'certain selected ones of the first plurality of software modules' 7, 4, 5, 2, and 3 and the 'certain selected ones of the second plurality of software modules' 16, 13, 14, 11, and 12 which are selected from the Data Conditioner 46 and the Decision Tool 50 by the workflow harness 44 and which are executed by the processor 20a of the computer system 20 of figure 1, is illustrated. In figure 13, in response to the 'Input Data 1' 22a, the 'certain selected ones of the first plurality of software modules' 7, 4, 5, 2, and 3 are executed in sequence by processor 20a; then, in response to the 'Conditioned Data' 48a, the 'certain selected ones of the second plurality of software modules' 16, 13, 14, 11, and 12 are executed in sequence thereby generating the 'Decision Tool Product for User Objective 1' 20b1A.

(0044)    In figures 12-13, the user introduced a first user objective (User Objective 1) and a first set of input data (Input Data 1) for the purpose of ultimately generating the 'Decision Tool Product for User Objective 1' 20b1A. In the following paragraphs, assume that the user introduces a second user objective (User Objective 2) and a second set of input data (Input Data 2) for the purpose of ultimately generating a 'Decision Tool Product for User Objective 2' 20b1B.

(0045)    In figure 14, assume that the user introduces, as input data, the following information into the Single Well Predictive Model (SWPM) software based computer system 20 of figure 1: (1) a second set of User Objectives (i.e., User Objective 2) 24b, and (2) a second set of Input Data (i.e., Input Data 2) 22b. The second set of Input Data 22b are input to the workflow harness 44. The second set of User Objectives 24b are input to the Workflow Storage 40, and, responsive thereto, a second specific workflow (specific workflow 2) 42b corresponding to the second set of User Objectives 24b is generated from the workflow storage 40, the second specific workflow 42b being input to the Workflow Harness 44.

Recall that the Data Conditioner 46 includes a 'first plurality of software modules' 46a including the following software modules: software module 1, software module 2, software module 3, software module 4, software module 5, software module 6, software module 7, software module 8, and software module 9. Recall that the Decision Tool 50 includes a 'second plurality of software modules' 50a including the following software modules: software module 10, software module 11, software module 12, software module 13, software module 14, software module 15, software module 16, software module 17, and software module 18. In response to the second specific workflow 42b, the workflow harness 44 will choose 'certain selected ones of the first plurality of software modules' 7, 8, 9, 6, and 3 embodied within the Data Conditioner 46. In figure 14, the 'certain selected ones of the first plurality of software modules' 7, 8, 9, 6, and 3 consist of the following software modules: software module 7, software module 8, software module 9, software module 6, and software module 3. Then, in response to the second specific workflow 42b, the workflow harness 44 will also choose 'certain selected ones of the second plurality of software modules' 17, 14, 11, 12, and 15 embodied within the Decision Tool 50. The 'certain selected ones of the second plurality of software modules' 17, 14, 11, 12, and 15 consist of the following software modules: software module 17, software module 14, software module 11, software module 12, and software module 15. The 'certain selected ones of the first plurality of software modules' 7, 8, 9, 6, and 3 embodied within the Data Conditioner 46 will be executed in sequence by the processor 20a of the computer system 20 of figure 1 in response to the 'Input Data 2' 22b thereby generating the Data Conditioner Products 48. The Data Conditioner Products 48 will include and will therefore generate a set of 'Conditioned Data' 48b (e.g., calibrated data). Then, in response to the 'Conditioned Data' 48b, the 'certain selected ones of the second plurality of software modules' 17, 14, 11, 12, and 15 embodied within the Decision Tool 50 will then be executed in sequence by the processor 20a of the computer system 20 of figure 1 (while using the Conditioned Data 48b) thereby generating the 'Decision Tool Product for User Objective 2' 20b1B.

(0046)    In figure 15, the 'specific workflow 2' 42b of figure 14, including the 'certain selected ones of the first plurality of software modules' 7, 8, 9, 6, and 3 and the 'certain selected ones of the second plurality of software modules' 17, 14, 11, 12, and 15 which are selected from the Data Conditioner 46 and the Decision Tool 50 by the workflow harness 44 and which are executed by the processor 20a of the computer system 20 of figure 1, is illustrated. In figure 15, in response to the 'Input Data 2' 22b, the 'certain selected ones of the first plurality of software modules' 7, 8, 9, 6, and 3 are executed in sequence by processor 20a; then, in response to the 'Conditioned Data' 48b, the 'certain selected ones of the second set of software modules' 17, 14, 11, 12, and 15 are executed in sequence thereby generating the 'Decision Tool Product for User Objective 2' 20b1B.

(0047)    In figures 14-15, the user introduced a second user objective (User Objective 2) and a second set of input data (Input Data 2) for the purpose of ultimately generating the 'Decision Tool Product for User Objective 2' 20b1B. In the following paragraphs, assume that the user introduces a third user objective (User Objective 3) and a third set of input data (Input Data 3) for the purpose of ultimately generating a 'Decision Tool Product for User Objective 3' 20b1C.

(0048)    In figure 16, assume that the user introduces, as input data, the following information into the Single Well Predictive Model (SWPM) software based computer system 20 of figure 1: (1) a third set of User Objectives (i.e., User Objective 3) 24c, and (2) a third set of Input Data (i.e., Input Data 3) 22c. The third set of Input Data 22c are input to the workflow harness 44. The third set of User Objectives 24c are input to the Workflow Storage 40, and, responsive thereto, a third specific workflow (specific workflow 3) 42c corresponding to the third set of User Objectives 24c is generated from the workflow storage 40, the third specific workflow 42c being input to the Workflow Harness 44. Recall that the Data Conditioner 46 includes a 'first plurality of software modules' 46a including the following software modules: software module 1, software module 2,

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software module 3, software module 4, software module 5, software module 6, software module 7, software module 8, and software module 9. Recall that the Decision Tool 50 includes a 'second plurality of software modules' 50a including the following software modules: software module 10, software module 11, software module 12, software module 13, software module 14, software module 15, software module 16, software module 17, and software module 18. In response to the third specific workflow 42c, the workflow harness 44 will choose 'certain selected ones of the first plurality of software modules' 7, 4, 1, 2, and 3 embodied within the Data Conditioner 46. In figure 16, the 'certain selected ones of the first plurality of software modules' 7, 4, 1, 2, and 3 consist of the following software modules: software module 7, software module 4, software module 1, software module 2, and software module 3. Then, in response to the third specific workflow 42c, the workflow harness 44 will also choose 'certain selected ones of the second plurality of software modules' 18, 17, 14, 15, and 12 embodied within the Decision Tool 50. The 'certain selected ones of the second plurality of software modules' 18, 17, 14, 15, and 12 consist of the following software modules: software module 18, software module 17, software module 14, software module 15, and software module 12. The 'certain selected ones of the first plurality of software modules' 7, 4, 1, 2, and 3 embodied within the Data Conditioner 46 will be executed in sequence by the processor 20a of the computer system 20 of figure 1 in response to the 'Input Data 3' 22c thereby generating the Data Conditioner Products 48. The Data Conditioner Products 48 will include and will therefore generate a set of 'Conditioned Data' 48c (e.g., calibrated data). Then, in response to the 'Conditioned Data' 48c, the 'certain selected ones of the second plurality of software modules' 18, 17, 14, 15, and 12 embodied within the Decision Tool 50 will then be executed in sequence by the processor 20a of the computer system 20 of figure 1 (while using the Conditioned Data 48c) thereby generating the 'Decision Tool Product for User Objective 3' 20b1C.

(0049)    In figure 17, the 'specific workflow 3' 42c of figure 16, including the

'certain selected ones of the first plurality of software modules' 7, 4, 1, 2, and 3

and the 'certain selected ones of the second plurality of software modules' 18, 17,

14, 15, and 12 which are selected from the Data Conditioner 46 and the Decision

5        Tool 50 by the workflow harness 44 and which are executed by the processor 20a

of the computer system 20 of figure 1, is illustrated.  In figure 17, in response to

the 'Input Data 3' 22c, the 'certain selected ones of the first plurality of software

modules' 7, 4, 1, 2, and 3 are executed in sequence by processor 20a; then, in

response to the 'Conditioned Data' 48c, the 'certain selected ones of the second

10       plurality of software modules' 18, 17, 14, 15, and 12 are executed in sequence

thereby generating the 'Decision Tool Product for User Objective 3' 20b1C.


(0050)    The invention being thus described, it will be obvious that the same may

be varied in many ways.  Such variations are not to be regarded as a departure

15       from the spirit and scope of the invention, and all such modifications as would be

obvious to one skilled in the art are intended to be included within the scope of

the following claims.